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UNITED STATES.

United States quarantine regulations to be enforced against plague.

DEPARTMENT OF STATE, *Washington, January 19, 1897.*

SIR: Referring to your letter of the 18th instant, I have the honor to inform you that our consul at Bombay was yesterday instructed by cable in accordance with your request, as follows:

"Treasury quarantine cholera regulations apply to plague, with fifteen days' detention exposed persons."

I have the honor to be, sir, your obedient servant,

RICHARD OLNEY,
Secretary of State.

Hon. SECRETARY OF THE TREASURY.

[Reports to the Supervising Surgeon-General United States Marine-Hospital Service.]

FORMALDEHYDE AS A DISINFECTING AGENT AND ITS PRACTICAL APPLICATION.

HYGIENIC LABORATORY, U. S. MARINE-HOSPITAL SERVICE,
January 29, 1897.

SIR: In view of great interest manifested by the health authorities concerning the use of formaldehyde gas as a disinfecting agent, I have the honor to transmit herewith an article on this subject, which embodies the results of investigations conducted in the hygienic laboratory.

Respectfully submitted,

J. J. KINYOUN,
Passed Assistant Surgeon, U. S. M. H. S.

The substance designated as formaldehyde has been known since 1868. It was discovered by Von Hoffman. He obtained it from wood alcohol by passing the vapor of the alcohol mixed with air over finely divided platinum or copper. It was considered

more or less of a chemical curiosity until a few years ago, when the manner of production was brought to a more perfect state and the cost of methyl alcohol was lessened.

The principle upon which this agent is now produced is practically the same process as described by Von Hoffman. Quite a number of apparatus have been devised for this purpose. Among these the one of Trillat is perhaps the best for generating it in large quantities for the manufacture of formalin or formol. This apparatus volatilizes the alcohol when the vapor is mixed with a requisite amount of air and impinged on platinum, platinized asbestos, or upon heated coke

In 1894, while in Berlin, my attention was called to a product of the chemical works of E. Schering, known to the trade under the name of "Formalin." This was a watery solution containing about 40 per cent of formaldehyde gas. It was claimed that this solution possessed disinfecting properties to a wonderful degree, and was equal to bichloride of mercury as a germicide.

During the early part of 1895 preparations were made to take up the subject, with a view to determining the availability of such solutions for preparing specimens for museum purposes, as well as for class demonstrations, and it was found to suit the purpose admirably. Soon after this experiments were undertaken to determine whether its range of usefulness could not be extended to the domain of practical disinfection As my former experiences with gaseous disinfectants had not given flattering results, I was quite skeptical of the claims which were beginning to be advanced concerning the efficiency of this agent.

The literature on the production of formaldehyde gas and its estimation is quite replete, while the literature of formaldehyde as a disinfectant is not only small but conflicting On account of this it has become necessary to review the subject at length in an attempt to arrive at a conclusion.

FORMALIN AS A GERMICIDE.

As a preliminary to the subject it was necessary to confirm or disprove many of the statements of those who had written upon this subject. This part of the work has been assigned chiefly to my colleague, Passed Assistant Surgeon Geddings, who has been associated with me in conducting the numerous experiments. There seems to be little variation in the conclusions of observers on the antiseptic and disinfecting properties of the solution of "formalin" or "formol." The results were fairly constant. The strength of the solutions required to inhibit the growth of micro-organisms, notably anthrax spores, has been stated to be 1–15000 by some, while others place it at 1–2000. Our results were 1–2000; as a germicide 1–10000 retarded growth.

The following tables are taken as comparisons:

Results obtained with formic aldehyde.

MIQUEL.		K. WALTER.	
Strength of solutions.		Concentration.	Anthrax.
1 : 10000	Putrified bouillon + m. (1)	2 : 100	No growth.
1 : 5000	Do. + m.	1 : 100	No growth.
1 : 3333	Do. + m.	2 : 1000	No growth.
1 : 2500	Do. + m.	1 : 1000	No growth.
1 : 2000	Bouillon unaltered.	1 : 2000	No growth.
1 : 1666	Do.	1 : 500	No growth.
1 : 1430	Do.	1 : 10000	No growth.
1 : 1250	Do.	1 : 20000	Slight growth.
1 : 1111	Do.	1 : 50000	Rich growth.
1 : 1000	Do.	1 : 100000	Rich growth.
1 : 910	Do.	Control	Rich growth.
1 : 833	Do.		

HYGIENIC LABORATORY, UNITED STATES MARINE-HOSPITAL SERVICE.

EXPERIMENT I.

Formalin in solution 1–5000 for the time below indicated.

Organism.	Control.	1 min.	2 min.	3 min.	5 min.	10 min.	15 min.	30 min.	60 min.
Staph. pyogenes Au	Growth	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth retard.	Growth retard.
B. Diphth	Growth.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.
	Formalin solution 1–4000 for the times named.								
Staph. pyogenes Au	Growth.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth retard.	Growth retard.	Growth retard.
B. Diphth	Growth.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth normal.	Growth retard.	Growth retard.
	Formalin solution 1–3000 for the times named.								
B. Diphth	Growth.	Growth retard.	Growth retard.	Growth retard.	Growth retard.	Growth retard.	Growth retard.	Growth retard.	Growth retard.
	Formalin solution 1–2000 for the times named.								
B. Anthrac	Growth.	None.	None.	None.	None.	None.	None.	None.	None.
	Formalin solution 1–1000 for the time named.								
B. Anthrac.	Growth.	None.	None.	None.	None.	None.	None.	None.	None.
	Formalin solution 1–500 for the time named.								
B. Anthrac	Growth.	None.	None.	None.	None.	None.	None.	None.	None.

The experiments were conducted with two products of the formaldehyde gas, one known as "formalin," a watery solution containing 40 per cent of the gas by weight, and the other known as "formol," a solution in methyl alcohol containing about 40 per cent of the gas (this latter is inflammable). It is a well-known fact that when either of these solutions are exposed to the air they lose a considerable quantity of the gas—in fact, a quantity sufficiently large is thrown off to act as a disinfectant. Especially has it been observed, when these are exposed on large surfaces, in a small space, so energetic and efficient has this been that one is led at first to believe that all that is required for rapid and sufficient disinfection of articles and apartments would be to employ formaldehyde in this manner.

While this method has proven satisfactory for laboratory experiments, conducted on a small scale, it has been quite disappointing when applied to the disinfection of rooms and their contents. The reason for the discrepancy in the results appears to be due to the following: Solutions of formaldehyde when exposed to the air lose a certain proportion of their gas and aqueous vapor. After the evaporation has progressed for some time the liquid becomes more concentrated and the greater proportion of the formaldehyde gas is converted into a yellowish white amorphus substance known as trioxymethelene. In this state it gives off but a very slight amount of formaldehyde, and that slowly. On this account it would require very large quantities of the solution, if

the method were otherwise practicable. The experiments conducted to determine the germicidal properties of the gas were made by using a large bell jar, to which was attached a vacuum apparatus and a tubulated bottle filled with cotton wool saturated with formalin. A stream of air could be drawn through the formalinated cotton and thence to the bell jar until a saturated atmosphere of the gas was obtained. Cover slips, containing an even layer of the micro-organism to be tested, were prepared and dried and then exposed to this atmosphere, after which the gas was neutralized and the specimen planted over into bouillon or inoculated into animals, as the case required.

The following is a summary of the experiments:

EXPERIMENT II.

Results of experiments on the disinfecting and germicidal value of formalin (formaldehyde).

Bouillon cultures of the following organisms were spread on cover slips and allowed to dry, then exposed to the action of a saturated atmosphere of formalin for the time indicated, and the slips then planted into bouillon and kept at a temperature of 37° C. for 24 and 48 hours.

Organism.	Control.	1 min.	2 min.	3 min.	5 min.	10 min.	15 min.	30 min.	60 min.
Staph. Pyogenes Aur.	Growth.	None.	None.	None.	None.	None.	None.	None.	None.
	Results after forty-eight hours—the same as above.								
Spirillum Finkler Prior.	Growth.	None.	None.	None.	None.	None.	None.	None.	None.
	Confirmed by a second series of experiments with identical results.								
Spirillum cholera Asiat.	Growth.	Growth.	None.	None.	None.	None.	None.	None.	None.
	Similar results after forty-eight hours.								
B. Coli Com.	Growth.	Growth.	Growth.	Growth.	Growth.	None.	None.	None.	None.
	Similar results after forty-eight hours.								
B. typhoid	Growth.	Growth.	Growth.	Growth.	Growth.	None.	None.	None.	None.
	Similar results after forty-eight hours.								
B. Diphth.	Growth.	Growth.	Growth.	None.	None.	None.	None.	None.	None.
	Similar results in forty-eight hours.								
B. glanders	Growth.	Growth.	None.	None.	None.	None.	None.	None.	None.
	Similar results in forty-eight hours.								

EXPERIMENT II—Continued.

Dip. Pneum. partially dry.....	Growth.	Growth.	None.	None.	None.	None.	None.	None.	None.
Dip. Pneum. dried	Growth.	None.	None.	None.	None.	None.	None.	None.	None.
B. Pyocyan.....	Growth.	Growth.	None.	None.	None.	None.	None.	None.	None.
B. Anthrac. with spores.....	Growth.	Growth.	None.	None.	None.	None.	None.	None.	None.
	A second series of experiments gave identical results in forty-eight hours.								
B. Tetanus, fatal to mice.....	Death.	None.	None.	None.	None.	None.	None.	None.	None.
B. of bubonic plague.....	Growth.	None.	None.	None.	None.	None.	None.	None.	None.

The amount of gas evolved by this method is considerably more than when it is evolved by placing a given quantity in a receptacle and allowing it to be diffused by evaporation. It was found that 1.25 volumes per cent was evolved by the former method and about 1 volume per cent by the latter. Numerous experiments have been conducted upon the power of atmospheric solutions of this gas to sterilize fabrics and other articles which had been infected with some pathogenic bacteria. The results were in every way satisfactory, as the germs were quickly destroyed even when they were in a dried state. Articles containing cultures of bacteria, which were protected by several layers of the material, did not give the same results as in the former. The results were extremely varying and inconstant. The cause of this appeared to be due to the inability of the gas to penetrate into the interior of the fabrics. It was especially noticeable where there was any considerable moisture on the surfaces of the article. The moisture appeared to arrest the gas, much after the manner of moisture arresting the penetration of sulphur dioxide, but even to a greater degree.

Another factor which is equally responsible for preventing penetration is the fact that formaldehyde has the peculiar property of being absorbed, or perhaps forming a loose chemical combination with woolen goods, hair, and feathers. These substances when exposed to the action of the gas will absorb considerable quantities, and for sometime after they will slowly evolve formaldehyde, much after the manner of trioxymethelene. When these experiments were repeated on a larger scale—for instance, in a room—the results were even more variable, and the arrest of the gas on the surfaces by the moisture, etc., was even more apparent.

Statements have been made that for room disinfection all that is required is to saturate clothes with formalin and hang them up in the room; allow the room to be closed for a given time, when it will be found to be disinfected.

Our results do not confirm this.

At this juncture it might be well to remark upon the effects of the formaldehyde gas and its solutions upon textile fabrics, hair, fur, and leather. Experiments were made by subjecting samples of wool, cotton, fur, and leather goods of every description to crucial tests, using solutions of various strengths and a saturated atmosphere of the gas.

The results obtained were in every way satisfactory. Of over 225 different samples of wool, silk, cotton, linen, leather, and hair subjected, there was no change observed in textile character, even when they were soaked in a strong solution of the gas.

Effect on colors.—Little if any change occurred in the colors of the fabrics; only three of the number showed any change. These were two shades of violet, and one a light red. These were coal-tar colors, and were also quickly bleached by the sun.

Effect on metals.—Iron and steel are attacked by the gas, and more so by its solutions. Copper, brass, nickel, zinc, and gilt work are not acted upon. The effect of the substance on iron should be borne in mind if iron disinfecting chambers are used for applying the gas. If this be the case, the surface of the interior of the chamber should be protected by paint or varnish.

After subjecting textile fabrics to the action of the gas, there always remains a considerable quantity of the formaldehyde in combination with the materials, which is slowly given off for a considerable time thereafter. This is especially so in the case of mattresses and feather pillows.

This is best obviated by subsequently exposing the article to the fumes of ammonia, which neutralizes the fomaldehyde by converting it into a formamide—a rather stable body, possessing germicidal properties of no small value, and not prone to undergo decomposition. Dr. Geddings' experiments with formamide give the following effects on anthrax spores:

EXPERIMENTS WITH FORMAMIDE.

EXPERIMENT III.

To formalin (containing 40 per cent formaldehyde) was added an equal volume of strong ammonia water (26° B. 20 per cent), and the resulting formamide obtained by evaporation to dryness. The salt was dissolved in bouillon in the following percentages, and the following organisms subjected to experiment therewith:

Organism.	Control.	1 per cent.	2 per cent.	3 per cent.	4 per cent.	5 per cent.	6 per cent.	7 per cent.	8 per cent.	9 per cent.	10 per cent.
B. Anthrac.....	Growth.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.

Organism.	Control.	0.1 per cent.	0.2 per cent.	0.3 per cent.	0.4 per cent.	0.5 per cent.	0.6 per cent.	0.7 per cent.	0.8 per cent.	0.9 per cent.	1 per cent.
B. Diphth.....	Growth.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.
B. Anthrac.....	Growth.	Growth.	None.	None.	None.	None.	None.	None.	None.	None.	None.

EXPERIMENT IV.

Formides of barium, calcium, sodium, copper, and silver—Their effect upon Anthrax spores.

[Time, twenty-four hours at 37° C.]

	Control.	1-100	1-200	1-300	1-400	1-500	1-600	1-700	1-800	1-900	1-1000
Anthrax.....	Growth.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.

No change in the above results in forty-eight and seventy-two hours at 37° C.

Agent.	Control.	1-1250.	1-1500.	1-2000.
Barium formide.....	Growth.	None.	None.	None.
Calcium formide.....	Growth.	None.	None.	None.
Sodium formide.....	Growth.	None.	None.	None.
Copper formide.....	Growth.	None.	None.	None.
Silver formide.....	Growth.	None.	None.	None.

Agent.	Control.	1-2500.	1-3000.
Barium formide.....	Growth.	None.	Growth.
Calcium formide.....	Growth.	None.	Growth.
Sodium formide.....	Growth.	None.	Growth.
Copper formide.....	Growth.	None.	Growth.
Silver formide.....	Growth.	Growth.	Growth.

No change in the above results in forty-eight and seventy-two hours at 37° C.

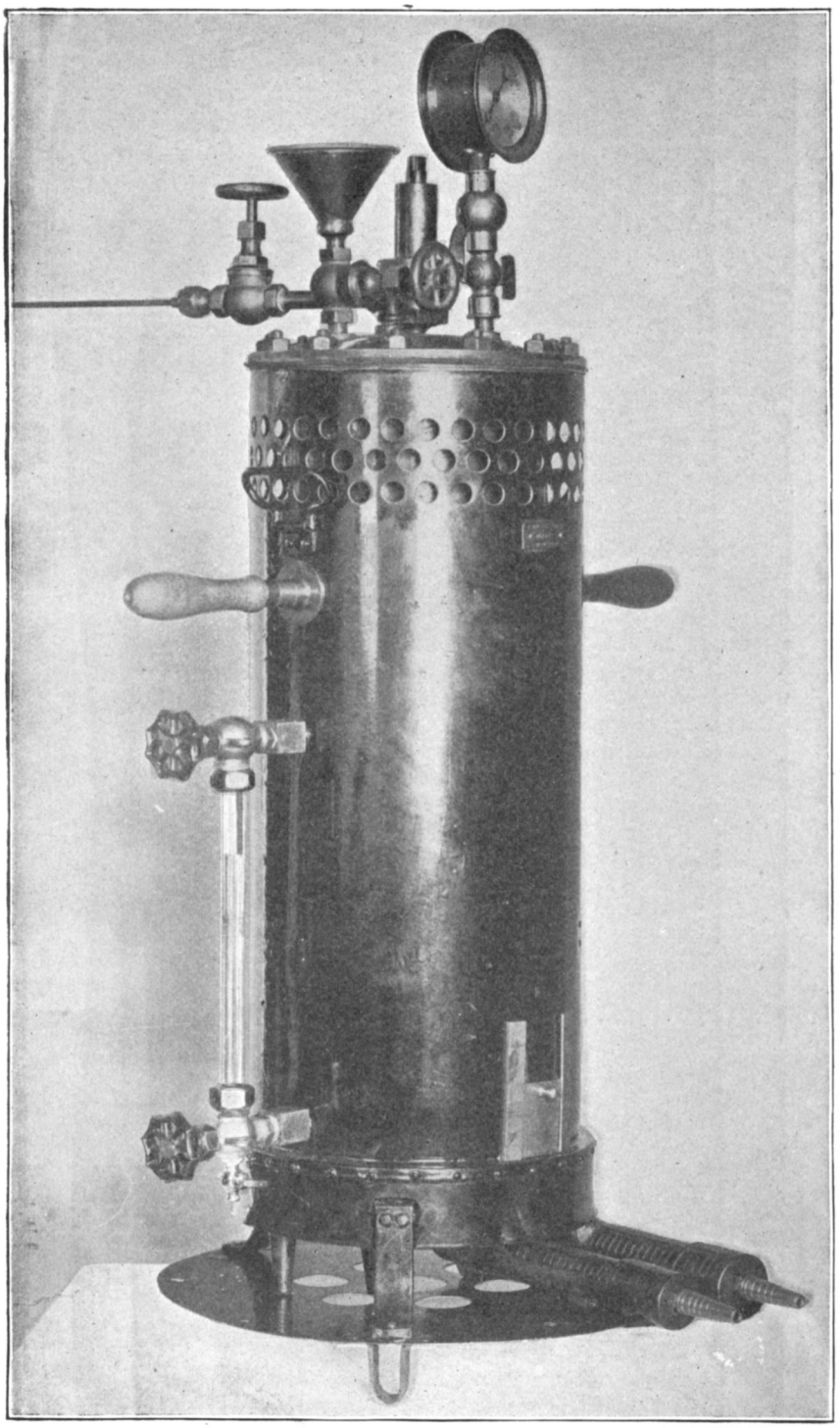


FIG. 1.

These experiments show that all these formides possess decided germicidal properties, and suggest their application to surgery, as they are much less poisonous than solutions of the same strength of mercuric chloride.

The formamide, particularly, would be useful in the sterilization and preparation of catgut suture materials. It would serve a double purpose in neutralizing the free formaldehyde in the catgut, and subsequently act as a preservative.

PENETRATION OF FORMALDEHYDE GAS.

Having observed the variable results attending exposures under ordinary conditions, it became apparent that some other means would have to be devised in order to have the gas penetrate the object readily and thoroughly. To this end, the vacuum process was brought into requisition. A small apparatus was arranged after the following manner: A large bell jar was attached to a vacuum pump, which by another opening was attached to a flask containing cotton wool saturated with formalin, or formol.

The jar was charged with the articles to be disinfected, and then closed; when a vacuum of half an atmosphere was produced, air was then allowed to pass through the formalinated cotton wool, replacing the air taken out of the bell jar. By this means cultures of pathogenic bacteria were readily killed, even when protected by several layers of woolen cloth. The only criticism which could be offered was that there was still a considerable quantity of moisture holding formaldehyde in suspension precipitated on the surfaces of the articles. Notwithstanding this drawback, these experiments were of great value in demonstrating how the bulkier objects can be penetrated by the gas. The manner in which the presence of moisture was prevented remained to be pointed out by Roux and Baudet, who have satisfactorily solved this difficulty. They employed special apparatus for evolving formaldehyde gas in practically a dry state, and in such quantities as were desired. They accomplished this by means of heating a small boiler, partly filled with the formalin solution, when the formaldehyde was driven off. In order to have the gas in as dry state as possible, the moisture is held back by means of a neutral chloride, preferably the chloride of calcium.

A given quantity of formalin is mixed with an equal quantity of 5 to 10 per cent solution of calcium chloride, as the boiling point of this mixture is considerably over 100° C. (from 103°–106°), and the most favorable temperature for evolving the formaldehyde gas is between 95° and 100° C. it can be seen wherein the advantage lies. Nearly all the gas is evolved before the water in the mixture is given off as steam. Moreover it presents the polymerization of the gas into trioxymethelene.

APPARATUS FOR EVOLVING FORMALDEHYDE GAS FROM FORMALIN.

Early in August of 1896, with the aid of Mr. J. B. Pratt, of the Coast and Geodetic Survey, plans for a similar boiler to that described by Roux and Baudet were designed and the boiler soon thereafter constructed. The apparatus is shown in an accompanying cut (Fig. 1). It is constructed after the following manner: A small boiler of $\frac{1}{8}$ inch copper, $6\frac{1}{2}$ inches in diameter by $17\frac{1}{2}$ inches high, closed at one end by a removable head, which is fastened to the boiler by bolts. It is capable of withstanding a pressure of 200 pounds to the square inch. On the head are the filling funnel, pressure gauge, safety valve, and discharge pipe. A drain pipe is fitted to the lower end of the boiler, and connects with the water gauge at the side. The boiler is supported by an iron collar or jacket, and is so arranged for applying heat. In the cut gas-burners are shown, but now a gasoline torch has been substituted for these. As this works so admirably it is recommended instead of the gas attachment. A pair of removable handles are attached near the top for transporting the boiler from place to place.

Method of operating.—The solution of calcium chloride is poured into the boiler, then the required amount of formalin; all valves and stopcocks closed and heat applied

through the opening under the boiler until the pressure registers from 75 to 90 pounds, when a small ½-inch pipe is attached and passed through the keyhole of the door of the apartment. The gas should be liberated rather rapidly. As soon as the pressure falls to about 5 pounds the boiler is again heated to the same degree as formerly, and again discharged. The two heatings set free nearly all the formaldehyde gas.

The amount of formaldehyde gas evolved from a liter of the formalin is about 1,450 liters—at ordinary temperature (17° C.). It can readily be calculated how much formalin will be required to form a certain per volume strength.

This apparatus is particularly adapted for the disinfection of rooms, and has been of great value as an aid in carrying out the several experiments.

ROOM DISINFECTION.

Through the courtesy of the health officer of the District of Columbia the wards and rooms of the new smallpox hospital were placed at our disposal for the purpose of making the proposed tests in the disinfection of rooms. The following are some of the experiments:

Room A.—Capacity, 7,400 cubic feet; percentage of formaldehyde, 0.5; time, 23 hours.

a. Character of experiment—cultures on Petri dishes, covered with filter paper, and enveloped in 10 layers of blanket: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, growth.

b. Cultures spread on cover slips, placed in double envelopes, one sealed with paraffin and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

c. Cultures on Petri dishes, covered with filter paper, and enveloped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth.

d. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

e. Cultures on Petri dishes, covered with filter paper, and enveloped loosely in a blanket gathered into a bag: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, no growth.

f. Cultures spread on cover slips, placed in double envelopes, and enveloped loosely in a blanket gathered into a bag: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, growth.

g. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in three sheets gathered loosely into a bag: Anthrax, growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, growth.

h. Cultures on cover slips, placed in double envelopes, the inner one sealed with paraffin, and exposed on mantel in room: Anthrax, growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

i. Cultures on Petri dishes, covered with filter paper, and exposed on mantel in room: Anthrax, no growth; typhoid, no growth; diphtheria, no growth.

k. Cultures on cover slips, in double sealed envelopes, placed between the leaves of a book, and exposed in the room: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

Room B.—Capacity, 10,500 cubic feet; percentage of formaldehyde, 0.25; time, 23½ hours.

a. Cultures on Petri dishes, covered with filter paper, and enveloped in 10 layers of blanket: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

b. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with

paraffin, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

c. Cultures on Petri dishes, covered with filter paper, and enveloped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth.

d. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and wrapped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, growth.

e. Cultures on Petri dishes, covered with filter paper, and wrapped in a blanket, loosely gathered into a bag: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, no growth.

f. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and wrapped in a blanket loosely gathered into a bag: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, no growth.

g. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and wrapped in three sheets loosely gathered into a bag: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, growth.

h. Petri dishes containing cultures and covered with filter paper, and exposed on mantel in room: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

i. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, no growth.

k. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and exposed in the interior of a closed book: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, growth.

Room C.—Capacity, 3,300 cubic feet; percentage of formaldehyde, 1.00; time, 22 hours.

a. Cultures on Petri dishes, covered with filter paper, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

b. Cultures, spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 10 layers of blanket: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, growth.

c. Cultures on Petri dishes, covered with filter paper, and wrapped in 36 layers of new cotton sheeting: Anthrax, growth; diphtheria, no growth.

d. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 36 layers of new cotton sheeting: Anthrax, lost; diphtheria, no growth; S. pyogenes aureus, growth.

e. Cultures in double envelopes, the inner one sealed with paraffin, and wrapped in folds of 3 sheets gathered into a bag: Anthrax, no growth; typhoid, no growth; diphtheria, no growth; S. pyogenes aureus, growth.

f. Cultures in Petri dishes, covered with filter paper, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; typhoid, no growth.

g. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

h. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and exposed between the leaves of a closed book: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

Room I.—Percentage formaldehyde, 2; time, 23 hours.

a. Cultures on Petri dishes, covered with filter paper, and wrapped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

b. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with

paraffin, and wrapped in 10 layers of blanket: Anthrax, no growth; diphtheria, no growth; S. pyogenes aureus, growth.

c. Culture on Petri dish, covered with filter paper, and wrapped in 36 layers of new cotton sheeting: Anthrax, growth.

d. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and wrapped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth; typhoid, growth; S. pyogenes aureus, growth.

e. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and exposed between the leaves of a closed book: Anthrax, growth; diphtheria, growth; typhoid, growth; S. pyogenes aureus, growth.

Room E.—Capacity, 3,300 cubic feet; percentage of formaldehyde, 1.00; time, 47½ hours.

a. Cultures on Petri dishes, covered with filter paper, and enveloped in 10 folds of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, no growth.

b. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

c. Cultures on Petri dishes, covered with filter paper, and enveloped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth; typhoid, no growth.

d. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 36 layers of new cotton sheeting: Anthrax, growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

e. Cultures on Petri dishes, covered with filter paper, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

f. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

g. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and exposed between the leaves of a closed book: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

Room F.—Capacity, 10,500 cubic feet; percentage of formaldehyde, 0.25; time, 48 hours.

a. Cultures on Petri dishes, covered with filter paper, and enveloped in 10 layers of blanket: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

b. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, growth.

c. Cultures on Petri dishes, covered with filter paper, and enveloped in 36 layers of new cotton sheeting: Anthrax, growth; diphtheria, no growth.

d. Cultures spread on cover slips, placed in double envelopes, the inner one sealed with paraffin, and enveloped in 36 layers of new cotton sheeting: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

e. Cultures on Petri dishes, covered with filter paper, and enveloped in the folds of 1 blanket gathered loosely into a bag: Anthrax, growth; diphtheria, no growth; S. pyogenes ureus, no growth.

f. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and enveloped in the folds of a blanket gathered loosely into a bag; Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, no growth.

g. Cultures spread on cover slips and placed in double envelopes, the inner one

sealed with paraffin, and enveloped in the folds of 3 sheets gathered loosely into a bag: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

h. Cultures on Petri dishes, covered with filter paper, and exposed on mantel in room: Anthrax, growth; diphtheria, no growth; typhoid, no growth.

i. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and exposed on mantel in room: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, no growth.

k. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and exposed between the leaves of a closed book: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, growth.

Room G.—Capacity, 7,400 cubic feet; percentage of formaldehyde, 0.50; time, 48 hours.

a. Cultures on Petri dishes, covered with filter paper, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

b. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and enveloped in 10 layers of blanket; Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

c. Cultures on Petri dishes, covered with filter paper, and enveloped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth.

d. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and enveloped in 36 layers of new cotton sheeting: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, growth.

e. Cultures on Petri dishes, covered with filter paper, and enveloped in folds of a blanket loosely gathered into a bag: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

f. Cultures spread on cover slips and placed in envelopes, the inner one sealed with paraffin, and enveloped in the folds of a blanket gathered loosely into a bag: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, no growth.

g. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and enveloped in the folds of 3 sheets loosely gathered into a bag: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, growth.

h. Cultures on Petri dishes, covered with filter paper, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; typhoid, no growth.

i. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and exposed on mantel in room: Anthrax, no growth; diphtheria, no growth; typhoid, no growth; S. pyogenes aureus, growth.

k. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and exposed between the leaves of a closed book: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, growth.

Room H.—Capacity, 930 cubic feet; percentage of formaldehyde, 2.00; time, 47 hours.

a. Cultures on Petri dishes, covered with filter paper, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, no growth.

b. Cultures spread on cover slips and placed in double envelopes, the inner one sealed with paraffin, and enveloped in 10 layers of blanket: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, growth.

c. Cultures on Petri dishes, covered with filter paper, and enveloped in 36 layers of new cotton sheeting: Anthrax, no growth; diphtheria, no growth.

d. Cultures spread on cover slips and placed in double envelopes, the inner one sealed

with paraffin, and enveloped in 36 layers of new cotton sheeting: Anthrax, growth; diphtheria, no growth; S. pyogenes aureus, no growth.

e. Cultures on Petri dishes, covered with filter paper, and exposed on floor of room: 3 anthrax, no growth; diphtheria, no growth; typhoid, no growth.

f. Cultures in double envelopes, exposed between the leaves of a closed book: Anthrax, growth; diphtheria, growth; S. pyogenes aureus, growth.

The above experiments demonstrate that the gas is a reliable disinfectant for surfaces and for the lighter articles, such as curtain hangings, clothing, carpets, and bed coverings. The gas was germicidal in all save where the test cultures were tightly wrapped in many layers of the fabric. Interiors of books were difficult to disinfect.

It is doubtful whether the interior of articles such as upholstered furniture, mattresses, and pillows can always be disinfected unless a much larger percentage of the gas is applied than was used in the above experiments.

The main obstacle in the way of applying formaldehyde gas, or any other gaseous disinfectant for that matter, is in not being able to close the apartment sufficiently tight to prevent the escape of the larger part of the gas. In our experiments extra precaution was taken to close all avenues, and yet, notwithstanding this, there was but little gas present, in comparison, after thirty-six hours had elapsed. The only way this can be guarded against is by using an excess of the gas. Just in what proportion the excess should be will entirely depend upon the local conditions.

It occurs that the length of exposure is secondary to the amount of gas used. A large per volume strength will accomplish the object better and in a shorter time than by using a small amount of the gas and prolonging the exposure. For room disinfection, under favorable conditions, fully twelve hours' exposure should be given. After twenty-four hours it is believed little or nothing will be accomplished.

DEVICE FOR USING FORMALDEHYDE GAS IN CONNECTION WITH DISINFECTING CHAMBERS.

Taking advantage of our experiences, I am convinced that as a matter of economical application and for absolute certainty of disinfecting, the following method of applying the gas to the bulkier objects, difficult of penetration, will commend itself. This, I may say, is a modification of the method which was first proposed by the writer in 1895, while at Denver, Colo., and later at the meetings of the American Public Health Association at Buffalo, N. Y.

Formaldehyde gas in the dry state penetrates rather slowly but surely. The process can be greatly hastened if a vacuum be used in conjunction with it.

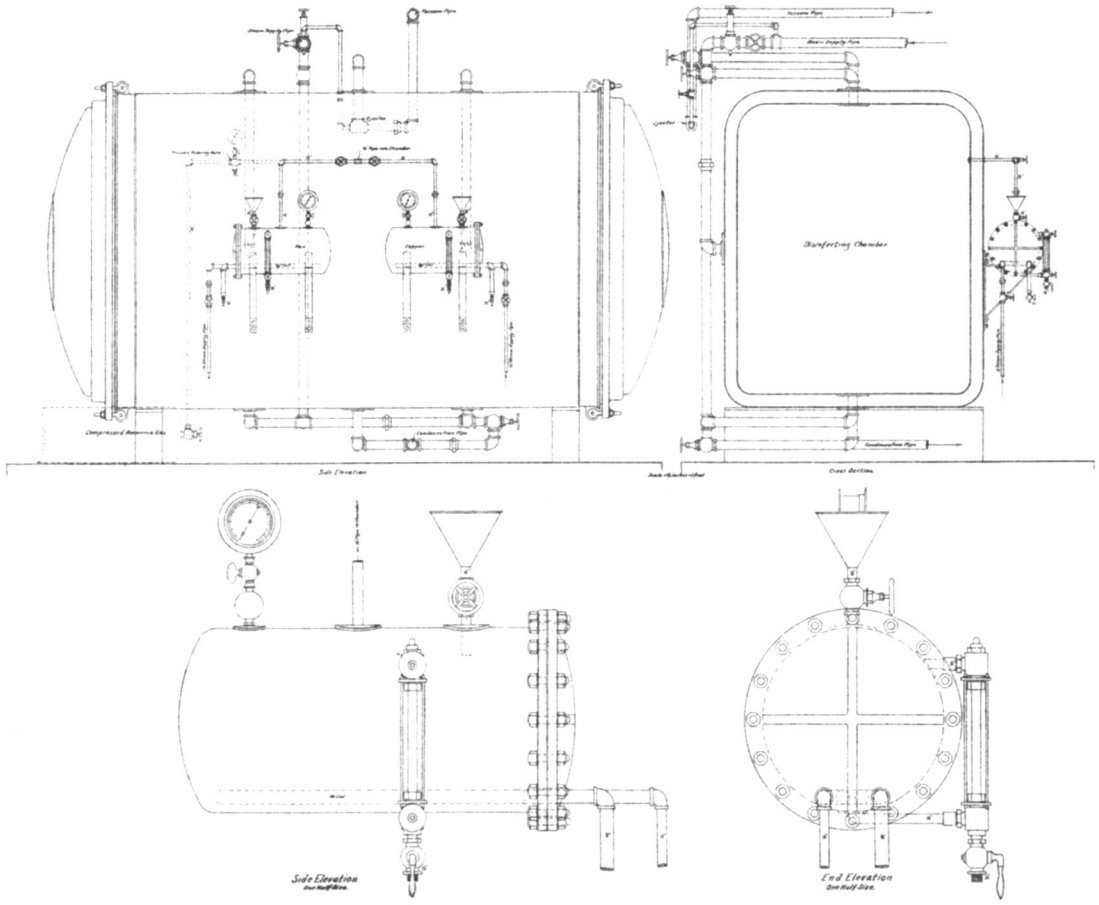
An attachment for the application of the gas has been devised, so that the ordinary steam disinfecting chamber can be adapted for this purpose. The proposed apparatus is delineated in the accompanying illustration under Fig. 2. It consists essentially of the following: Two small boilers, one of copper and the other iron, are provided with coils of steam pipe for heating the liquids. On the top or upper side are placed the filling attachment, pressure gauge, and discharge pipes. On the sides are the water gauges and drips. The discharge pipes of both boilers are connected with the interior of the disinfecting chambers by a common opening. The copper boiler is intended to be used in the same manner as the portable formalin boiler hereinbefore described (Fig. 1). The one constructed of iron is intended for using solutions of ammonia for neutralizing the formaldehyde gas on completion of the disinfection.

Compressed ammonia gas can be substituted for the second boiler. The ammonia gas can be let into the chamber by means of a pressure regulating valve. This method is preferable where a large amount of disinfection is carried on.

Method of operating.—The chamber is charged with the articles to be disinfected; the doors closed and made fast, and the air exhausted by means of the vacuum apparatus, to within half an atmosphere. Synchronously with this operation, the mixture

Showing attachment of boilers, etc., to steam disinfecting chamber.

FIG. 2.



Small boiler for evolving formaldehyde gas from formalin, or formol.

of calcium chloride and formalin is prepared and poured into the copper boiler and steam allowed to course through the spiral heating coil, and continued until a pressure of from 75 to 90 pounds is obtained. The gas is then turned into the chamber. If the vacuum gauge still shows a vacuum, the process can be repeated until the pressure is zero.

In this way one can readily obtain any desired percentage of the gas, and the time of exposure be governed accordingly. After the articles have been subjected to the gas for a sufficient time, the vacuum process is again started and half the atmosphere removed. Ammonia water is poured into the iron boiler and heated by means of the steam coil. It can then be thrown into the chamber, after the same maner as the formalin. The ammonia should be in excess of the quantity of formaldehyde gas. After 10 to 15 minutes the process is completed. This process is especially adapted for disinfecting mattresses, pillows, blankets, upholstered furniture, heavy rugs, furs, and books, and the mails; also, for the very fine textile fabrics, especially costumes and the like.

The advantages of such an apparatus are obvious: (1) Certainty of penetration of the objects; (2) reducing the time of exposure to a minimum and increasing the capacity of the chamber; (3) the quantity of the gas can always be gauged; (4) little or no injury to fabrics; (5) economy over steam.

Such an attachment can be made to any of the steam disinfecting chambers now in use without interfering in any way with their usefulness for steam disinfection. If a special chamber for formaldehyde disinfection is desired, it is recommended that a single-walled chamber, circular in form, be substituted for the jacketed steam chambers. While both these processes answer the requirements for the disinfection of rooms and their contents, the use of the formalin boiler is rendered a rather expensive procedure on account of the present price of the formalin. All the formalin or formol now used is of foreign manufacture.

LAMPS FOR EVOLVING FORMALDEHYDE GAS FROM METHYL ALCOHOL.

Quite a number of writers have suggested the use of a lamp or some such apparatus for converting methyl alcohol into formaldehyde gas. Several lamps are now to be had for this purpose. As said before, these lamps and apparatus are constructed on the principles of the Von Hoffman or Trillat processes.

Some of the lamps, notably the Bartheil and one constructed by Adnet, are claimed to be efficient for disinfection of rooms. Professor Robinson, of Bowdoin College, has recently perfected a similar lamp, which he claims to be quite efficient. So, also, has Dr. de Schweinetz, of Washington.

The amount of formaldehyde produced by any of these lamps is not believed to be as great as is claimed for them—that is to say, that the amount of alcohol consumed does not represent in proportion the amount of formaldehyde. It is believed that only a part of the alcohol is changed; the rest is either converted into a higher state of oxidation or is volatilized by the heat.

If such a lamp will generate a sufficient quantity of formaldehyde gas for disinfection of a room, and it is meant by this simply a surface disinfection, it will be a great improvement over the present method. Sulphur gas has proven so inefficient that it is hardly worth considering.

It has been my purpose to study this subject in all its lights, with a hope that a simple apparatus could be devised by which surface disinfection could be reliably performed.

Lamps which contain free alcohol—that is, contain any considerable quantity in reservoirs, may, under certain unlooked-for conditions, ignite or explode.

This is a serious objection. A lamp to meet all requirements for room (surface) disinfection should be so constructed as to preclude any such accident.

I have recently devised several modifications of the lamps, and have had a lamp constructed which appears to better meet these objections.

While this lamp does not consume as much alcohol within a given time as is claimed for others, it combines safety, simplicity, cheapness, and efficiency.

My thanks are also due to the Coast and Geodetic Survey for many valuable suggestions, and for the preparation of the drawings and the building of experimental lamps.

The lamp, as shown in the accompanying illustration (Fig. 3), consists of three parts; a lamp bowl, a collar, containing converter, and a hood, and is constructed after the following manner:

The lamp bowl is made from a five-quart milk pan, and filled with ordinary mineral wool, such as is used for insulating pipe, etc.

The collar is made of sheet iron; the lower edge is made to fit closely over the shoulder of the lamp bowl, 8 inches above a number of perforations (92) for draught. Nine inches above a groove is turned on the collar, upon which lies a disk of platinized asbestos, supported by a number of cross wires. The collar is extended about 5 inches above this disk, and acts as a chimney. Just about a half inch above the top of the lamp bowl is inserted a disk of perforated tin. This acts as a damper or radiator, and prevents the undue volatilization of the alcohol by heat from the asbestos disk.

A hood is also provided, which fits closely over the top, and extending down below the draught holes. The efficiency of the lamp lies altogether in the character and construction of the platinized asbestos disk.

This is made of an extra hard pressed asbestos millboard, $\frac{1}{8}$-inch thick, and is perforated with $\frac{1}{8}$-inch holes one-half an inch apart.

The best asbestos for this purpose is furnished by the H. W. Zahn's Manufacturing Company of New York.

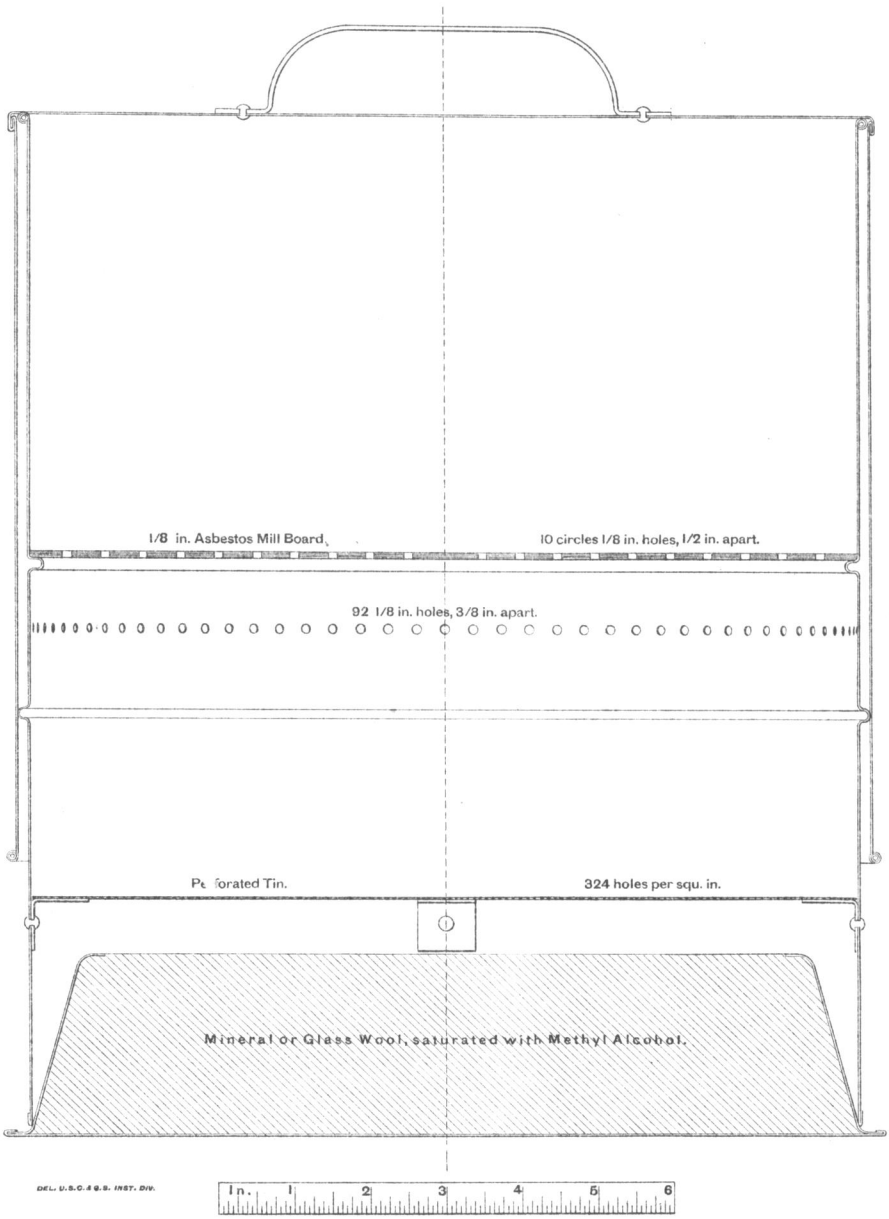
Platinizing the disk.—About 0.3 gram of platinic chloride is dissolved in 150 c. c. of alcohol or water. The disk is placed in a flat-bottomed vessel and the solution is then poured over it and allowed to thoroughly saturate it, after which it is placed in the iron collar and moulded in place. It is then ignited and the alcohol burned off. The perforated tin disk is removed and the collar placed over the lamp in the same position as if for heating it for disinfection. The alcohol is ignited and allowed to burn until the platinic chloride is converted into platinum black. It is then ready for use.

When the lamp is to be used, the collar is removed and the required amount of alcohol is poured over the mineral wool; this readily absorbs the alcohol and prevents any free alcohol from spilling should it be tipped over. It also prevents undue action of the flame should, by chance, it become ignited.

The collar is replaced over the lamp bowl so that one edge of the collar rests on the top of the lamp, and a half an inch or so of air space is around the bottom. The hood is removed and the alcohol lighted. The lamp is allowed to burn freely until the platinized disk of asbestos begins to glow slightly, when the hood is placed over the collar slowly, and then by means of the handle the collar is placed in proper position over the lamp bowl and pressed down so that the collar fits snugly.

After about 30 seconds remove the hood and observe whether the alcohol has ceased to burn. If not, replace the hood and again after 30 seconds remove, when the platinized disk should begin to glow and formaldehyde be given off. Sometimes, however, the lamp will ignite below at the draught holes and burn with a slight flame. This is caused by one of two things. First, the collar may not fit snugly around the lamp bowl; second, the perforated tin disk may have been heated too hot when the lamp was started. By placing the hood over the collar and waiting for about a minute this latter will be prevented.

It is intended that this lamp should be filled with the required amount of alcohol, placed in the apartment, started, and allowed to remain for the full time of exposure. The air of the apartment can be neutralized by ammonia fumes and then opened. The



Formaldehyde lamp. Cross section.

FIG. 3.

results obtained with this lamp have been quite satisfactory, especially with regard to disinfecting apartments infected with diphtheria.

I have not been able, however, at all times to disinfect the interior of pillows and mattresses with certainty, even when a very small room was used for this purpose and a large amount of methyl alcohol consumed. The surfaces, dust, etc., were every time rendered sterile.

QUANTITY OF ALCOHOL REQUIRED.

Not less than 500 c. c. of methyl alcohol should be used for each 1,000 cubic feet of space.

For disinfecting clothing and the light fabrics, it would be well to put them in as small a space as possible, and have the articles so arranged as to have all the surfaces freely exposed to the gas.

It is often required that a preliminary disinfection be given an infected apartment and contents before they are disturbed. This is, of course, a preliminary precaution which will, if properly performed, render the danger of dissemination of the infection less, by sterilizing the surfaces of the articles. Lamps could be used advantageously in such instances for the preliminary disinfection of the surfaces of such articles which it would be necessary to remove and treat by other processes. When this is done, the gas should be neutralized.

NEUTRALIZATION OF THE EXCESS OF FORMALDEHYDE GAS.

This is best accomplished by having a small tinned iron boiler, conical in shape, holding about three quarts, provided with a filling cock and tube on top. A rubber tube can be attached to this and fed into the apartment, through the door, preferably the keyhole. Ammonia water is poured into the boiler, stopcock closed, and then the boiler set in a bowl of boiling water. This will readily evolve the ammonia gas. A small kerosene lamp can be used instead of the boiling water.

TRIOXYMETHELENE.

Reference has been previously made to the substance known as trioxymethelene, or "paraform." This substance is formed when a 40 per cent solution of the gas is concentrated. It gives off formaldehyde gas slowly at ordinary temperatures, and when heated it breaks up into formaldehyde and formic acid.

It has been suggested that this substance could be used as a disinfecting powder. Miquel has demonstrated that it possesses germicidal properties sufficient to kill anthrax spores, provided the exposure be prolonged. It might be of value in disinfecting the packed effects of persons and merchandise coming from places where an epidemic prevails. But just how long the articles must be subjected can not now be determined.

OTHER METHODS OF USING FORMALIN.

Formalin or formol can be used in other ways than in the foregoing, it is believed, with excellent results. Although our experiments are still under way, it may now be said that the infected articles, such as packed effects, can be rendered sterile by the application of one of these solutions. It may be applied to the articles by sprinkling, or by moistening some absorbent substance with these and placing it among the clothing. Due care should be exercised to see that the agent is well distributed among the contents of the package. The packed effects of immigrants, not to be used on the voyage, could be disinfected by subjecting them to an application of formaldehyde. This should be performed under the supervision of the proper officer. The packages could then be sealed and not opened until arrival on this side. This procedure would relieve the quarantine of an enormous work, and reduce the danger of importation of infectious diseases from this source to a minimum.

Articles exposed to the infection of smallpox, yellow fever, plague, and cholera could be thus disinfected.

MAILS AND BOOKS.

Should be disinfected by the use of a disinfecting chamber and the vacuum process. Bundles of letters and papers should always be untied. Individual letters can be readily disinfected by placing in the envelope a small piece of blotting paper moistened with formalin or formol.

For mails coming from infected districts the disinfection might be accomplished in a similar manner as is recommended for the packed effects of persons. The mail matter could be sprinkled with formaldehyde solutions or placed in contact with some absorbent substance, moistened with formalin, placed in the mailing bags and closed. If allowed to remain in contact with the gas for several days, say the ordinary time of an ocean voyage between Europe and this country, it is believed that they will be incapable of transmitting infection. It would be necessary to neutralize the formaldehyde gas before they could be handled.

DISINFECTION ON SHIPBOARD.

In case of infection on shipboard, especially yellow fever, where it becomes necessary to disinfect all the wearing apparel and upholstered work and hangings with the least possible delay, a small room may be improvised into a formaldehyde disinfector after the following manner: Clothing that may possibly be injured by an excess of moisture can be protected by a cotton cloth. A layer of clothing is spread on the floor, then covered with a cotton cloth, then followed with cloth dipped into or sprinkled with formalin, and another cotton cloth, then another layer of clothing. The whole to be covered with a piece of tarpaulin and the edges weighted down. After an exposure of forty-eight hours the articles will be thoroughly disinfected. While this process is somewhat expensive it is much cheaper than buying new clothing or having them damaged by other methods.

Containers for clothing—packing cases for merchandise—can readily be disinfected by formaldehyde lamps. Care should be exercised, however, to use as small a space as possible, and have it tight.

DISINFECTION OF HOLDS OF VESSELS.

It would not be fair to say just how far formaldehyde gas will be applicable for this purpose. It may be possible, but in view of our experiments, it would appear that there are insuperable difficulties in the way of applying this agent in the presence of so much moisture, that it would answer at best as a surface disinfectant. This is, however, an opinion it may be possible to reverse when a series of experiments now under way is completed.

The lamps give off a large amount of water, which militates against the diffusion. Attempts have been made to dry the gas, but so far the drying agent either withholds the gas or breaks it up.

If it is found that the gas can be used for the disinfection of holds, it is believed that an apparatus designed on the principle of Trillat will give the best results. By this means as large a quantity as desired of the methyl alcohol can be consumed. It only depends upon the number of convertors. Experiments are now being made with such apparatus, with a view of determining the efficiency for disinfecting holds.

In conclusion, I would state that from the foregoing it would appear that this agent is destined to play no small part in our fight against infectious disease.

While it does not fill all the requirements of an ideal disinfectant, it is equal, if not superior, to any of our present methods.

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Smallpox in Pensacola.

PENSACOLA, FLA., *January 20, 1897.*

SIR: I reported to you yesterday 1 case of smallpox occurring in my private practice, and I am informed that 2 cases were sent to the pesthouse on the same date by the health authorities. The disease, in my opinion, is increasing instead of decreasing.

Respectfully, yours, J. WHITING HARGIS,
Acting Assistant Surgeon, U. S. M. H. S.